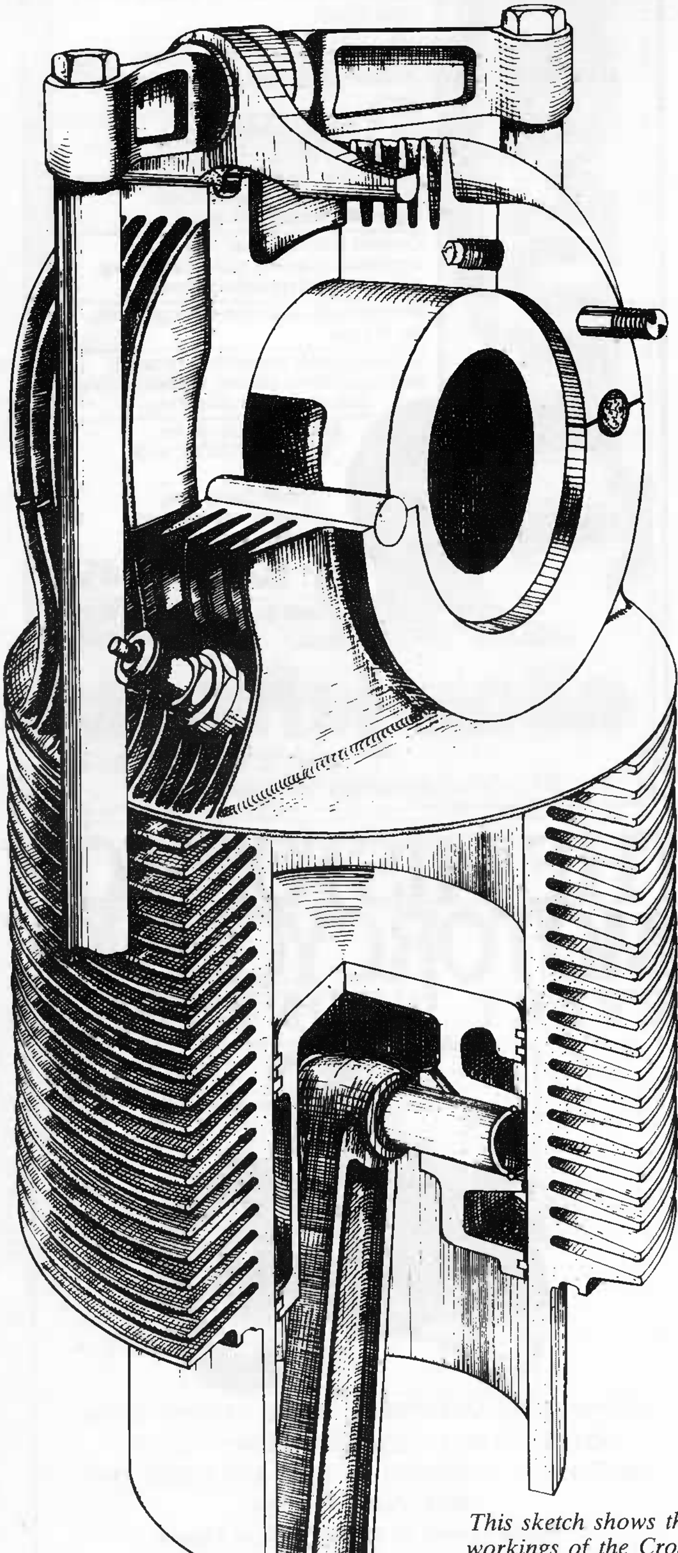
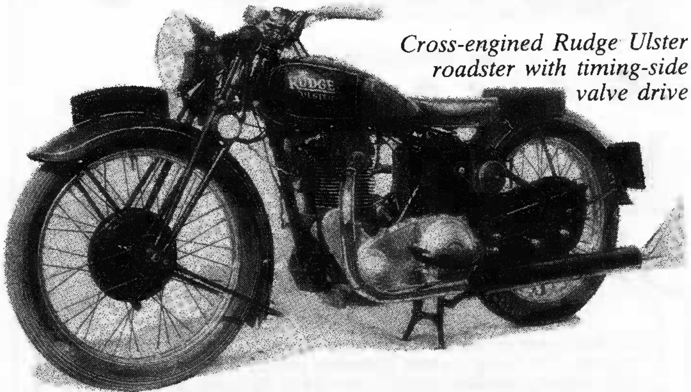
CROSS PURPOSES

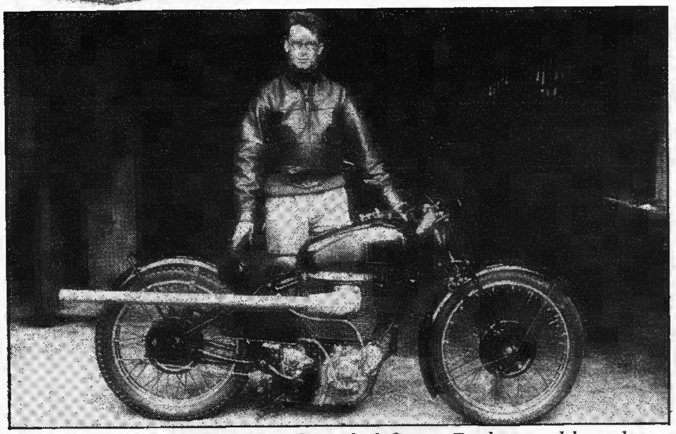
Despite extensive development, the rotary valve devised by Roland Cross never fulfilled its promise of power with economy. Story by Andrew Nahum



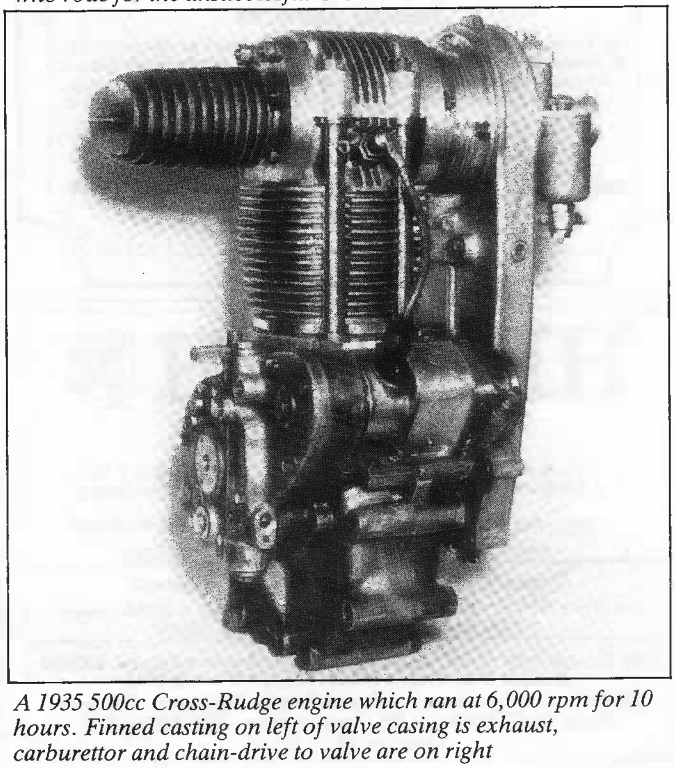
This sketch shows the workings of the Cross rotary valve in its ultimately developed form. The cylinder head and barrel are in one piece and allowed to float up and down, making sealing pressure at the valve rotor proportional to pressure in the cylinder. Long bolts secure the upper valve housing via a self-adjusting bridge piece. Illustration and photos courtesy of the Institution of Mechanical Engineers



Cross-engined Rudge Ulster roadster with timing-side valve drive



Built for the 1935 TT, the oil-cooled Cross-Rudge could not be made ready in time to race. Holding the machine is Les Martin, who rode for the unsuccessful Cross team



A 1935 500cc Cross-Rudge engine which ran at 6,000 rpm for 10 hours. Finned casting on left of valve casing is exhaust, carburettor and chain-drive to valve are on right

OVER the years, the challenge of improving the dull old petrol engine has exercised an almost hypnotic spell over the minds of inventors, who have searched for alternatives to the poppet valve. One such was Roland Cross, who worked for many years to try and perfect his rotary valve, and was perhaps the most influential of all experimenters in this field. Cross served his apprenticeship in Dumfries, with Arrol Johnston, then spent the first world war at the Bristol and Vickers aircraft companies, before returning to his native Bath to start a general engineering company.

During the war, the famous internal combustion engineer Harry Ricardo had done much useful work on petrol engine performance, and by the early twenties had conclusively proved the role of detonation in limiting engine output. He also stressed that the petrol engine is an air-breathing device — it must take in the fullest weight of air to give optimum performance and efficiency. Thus the importance of rapid valve opening and large ports began to be appreciated.

Ricardo became convinced that the single sleeve-valve was the solution to these problems, and through his influence with government committees Bristol were encouraged to develop their famous World War Two sleeve-valve aero engines. Roland Cross however, turned to the rotary valve. Rotary motion gave rapid port opening and closing, with an extraordinarily simple drive. Perhaps the most important asset, though, was that it eliminated the hot-spot created by the poppet exhaust valve.

In practice, the attraction was that single sleeve, or Cross-type rotary valve engines could run at one whole unit of compression ratio higher than poppet engines on the same fuel. It must be remembered that in those days it was the octane limitations of fuels which, more than anything, held down engine performance.

The first Cross engine was built from scratch in 1922. Thereafter he usually adapted existing engines, although he noted that it often took more work 'to join the head of the lion to the body of the tiger', as he described it, than to build a whole new engine. His second engine was a rotary valve conversion of the 500cc Sunbeam motorcycle which had been ridden by George Dance in the 1923 TT. This lapped Brooklands at over 80mph — good for the day, but no better than well-tuned conventional ohv types. He then converted an 1100cc Rhode car for normal use, which, he noted, was 'exceedingly smooth, quiet and would achieve a speed of about 70mph on any good road'.

Cross soon encountered the classic problem of rotary exhaust valves: moving surfaces need good lubrication, and where there is an oil film there is also a very definite thermal limitation. The whole story of rotary valve development has been that of trying to thread a course between seizure, good sealing, and

Roland Cross: looking beyond the poppet valve

excessive oil consumption. Cross developed a bronze bush for the valve housing, which eliminated piston ring and scraper seals by springing the lips of the bush inwards at the port to make a flexible seal that could follow the thermal expansion and contraction of the valve rotor. This allowed, for the first time, a circulatory rather than a (copious) constant-loss oiling system for the valve.

The next development of the valve — and the version in which it is best known — was to split the valve housing horizontally along the bolts to the crankcase, while the cylinder, carrying the lower half of the valve housing, is allowed to float vertically against the valve rotor. Thus the sealing pressure on the valve is made proportional to gas pressure in the cylinder, and at light loads the valve was subject to very little friction.

Cross recalled: 'The effect of the modification was remarkable. These engines now had wonderful gas sealing, and the slow pulling rivalled that of the steam engine.' A 750cc Austin Seven car engine with this type of valve held 30bhp continously on test with petrol of only 65 octane, and gave a sparkling performance.

In fact, full cylinder gas pressure gave a higher sealing load than necessary and Cross modified the valve further with an ingenious reaction bridge and hinge system to reduce mechanical advantage and lower the force. On some research models the force could even be adjusted during running, and the effect of power delivery at different rpm examined. This split-housing version can be regarded as the final development of the Cross valve.

Much of the experimentation was done on motorcycle engines — an air-cooled single-cylinder engine like a Rudge being relatively easy to modify, and to compare with state-of-the-art four-valve poppet breathing. One 350cc unit would run at a compression ratio of 10.5:1 on 87 octane fuel. Even on 65 octane petrol it gave 25bhp at 6,000rpm, and on the road, cruising at 60-65mph, it achieved 99mpg. No contemporary poppet valve engine could rival these figures.

Cross did fail, in some people's view, to prove the rotary valve's durability. An oil-cooled motor, based on the 500cc Rudge Ulster was built for the 1935 TT, running at a striking 12:1 compression ratio. It was not ready in time, so another, air-cooled, Cross-Rudge variant was used. However, this only completed one lap, at 67.8mph — compared with laps of just under 85mph from works Nortons — before it pulled into the pits with 'plug trouble'. It was said that its alloy valve-housing was in pieces.

The problem at high power outputs is that the exhaust passes inside the valve rotor over a large surface area and severe heat is inevitable. Success is perhaps more likely in a water-cooled engine, and to this end in the late thirties, the company built a liquid-cooled rotary-valve four-cylinder engine for an HRG hill-climb car, but it never performed as hoped.

This more or less marked the end of Cross' rotary valve experiments, but he engaged in several other areas of piston engine research. One was the early use of unlined aluminium alloy cylinder barrels, and while working on this he became discontented with the quality of the hard wire piston rings he had decided to use. Though made by experts, they had an appreciable in-built twist, calling for extra clearance in the ring grooves to avoid sticking.

Cross then made what he described as one of the rashest decisions of his career, and made his own rings. His first efforts failed dismally, but he eventually succeeded in hardening them while coiling and flattening the rings during the tempering process. The process was working well by 1940 and Cross was instructed by the Ministry of Aircraft Production to produce circlips and retaining rings for Bristol radial aero engines.

In the post-war years, the Cross company has found many applications for a process that can produce hardened coils to fine tolerances, and make piston rings for, among others, Cosworth. Their high-tensile sealing rings and labyrinth seals also found their way into gas turbines and the nuclear industry, and Royal Enfield enthusiasts may be familiar with the Cross seals used for the cylinder-head joint on the 750cc Interceptor twin.

On the basis of torque figures, fuel efficiency and tolerance of poor quality fuel, the rotary valve has a great deal to commend it: the only problem is getting it to work! Even such apostles of mechanical rectitude as the Norton racing shop flirted with a Laurie Bond-designed version similar to a Cross type in 1954. Though they got a Manx variant up to the 47bhp of the twin-cam version, it drank oil and still seized. Have we seen the last of the rotary valve petrol engine?